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SPACE AND TIME.

I. SPACE.

FEW categories have aroused more controversy than has space. The reason for this divergence of opinion lies, in part, in its basic character; in part, in its various forms and implications. Let the reader ask himself whether he can conceive the physical world apart from space? Does he not even locate—vaguely enough it may be—even his own sensations and emotions? Again, how many perplexing problems cluster around space as a center! Is the world infinite in extent or finite? Is it infinitely divisible? Is space a receptacle in which things somehow exist, or is it simply a term for the peculiar order of things? What is the relation between space and time? Are they absolutely antithetical as Bergson holds? Or are they supplementary and in a way correspondent? Is space reducible to time as some empiricists have held? Has each of us a private space? And, if so, is there a common space? Is space an entity, or subsistent, as neo-realists maintain? It is evident that enough questions can be, and have been, asked about this category. It would be easy to find material to write a weighty tome upon this category alone.

The consequence of this varied approach is that the field has become very complex; and so the unwary thinker is apt to become confused as he attempts to find his way about in the heaped-up literature. Each specialist envisages the topic from his own angle, and, in trying to be thorough, succeeds in making a treatise. In such a situa-

tion, it requires some temerity to attempt to cover the philosophical essentials in a brief article. And yet this is our task. But we can pluck hope from the fact that process and result are in a way incommensurable. Just as years of experimentation can be condensed into a single formula, so years of reflection and persistent pushing-through of a point of view can find relatively brief expression.

Space is a strategic category. The physical realist is called upon to defend its validity and self-consistency against the attacks of idealists. Important as this task is, I do not think that it is very difficult. Mathematicians have of late aided the philosopher by their very able analysis of space as a subsistential content involving position, order and distance. The majority of neo-realists have followed them in this work. But the critical realist has the further task of appreciating space as a category concerned with the physical world. The physical world is not simply subsistential space, and yet it has a "form" to which the character of such space is applicable. Scientific knowledge about nature contains spatial order as a primary ingredient. Physical existents can be located with reference to one another.

When the critical realist thinks of space as a category, he does not mean that space is a physical reality. He means only that valid knowledge of physical reality contains elements which can be universalized under such headings as distance, position, size, etc. We shall treat the category of quantity as intimately bound up with space, while fully admitting that there are quantities which are intensive rather than extensive. Knowledge of the physical world, then, contains such judgments as *that* this thing is to the right of that, this thing is ninety million miles from the earth, *that* these things are measurable in terms of an arbitrary unit adopted as a standard. All this is preliminary knowledge, if you will, but it is none the less valid.

This defense of space as a valid category marks one of the essential differences between a realistic naturalism and all forms of spiritualism. The antipathy of spiritualism to space is well known. Leibniz, its first protagonist, attacked the objective validity of space and maintained that reality consists of spaceless points which are in themselves immanently evolving spirits. For Schopenhauer, also, space is phenomenal and has no objective validity. Reality is of the nature of will. This agreement is no accident, for we find in Bergson, likewise, a tendency to belittle space at the expense of duration in consciousness. Space is stated to be homogeneity and simultaneity, while the self reveals itself to intuition as an interpenetrating flow of qualities. Space is here a sort of *pièce de résistance,* and the exact status of space and matter is not very clear; yet it seems certain that for him the higher levels of reality are non-spatial.

With the general attitude of neo-realism toward science the critical realist is in the heartiest sympathy. Still, the profound difference in epistemology has its necessary consequences.

The neo-realist is nearer naive realism than is the critical realist, yet he champions the non-mental reality of such entities as space, time and number. When he includes values of all sorts, he is led to attack naturalism with the fervor of the Platonist.[1] Neo-realism and Platonism have much in common; critical realism and Platonism have little in common. Of course, values are real just as sentiments, desires and judgments are. But they are entirely human affairs.

Evolutionary naturalism is a critical naturalism. It distinguishes between objective contents in the individual's experience and the physical objects of his knowledge. Thus

[1] Cf. Spaulding, *The New Rationalism,* p. 498. (Why not a "new naturalism" as well as a "new rationalism"?)

critical naturalism can do as full justice to mathematics and logic as Kant and Locke tried to do. The weakness of the older naturalism was its unreadiness to do justice to the reality of mind, mental entities and values.

A Genetic Approach.—We shall find it true of space—as of the other categories—that it has different levels and contexts. Therefore, our first task must be the separation of these levels and a relation of them to their proper universe of discourse.

The more highly developed kinds of space, while not simply reducible to the more primitive types, cannot be understood apart from them. They are a development, a clarification, of them. The categories which we apply to the physical world have their birth in the field of perception. It is this point which I wish to emphasize by this genetic approach. Discrimination and reflection play their part, but they must have material on which to work. This material consists of sensible characters given in consciousness.

Sensational Space.—The philosopher does not feel it his task to trace the spatial experience of the adult to its beginnings. It is for the psychologist to discover the various factors whose active synthesis leads somehow to the perceptual level at which we all naturally live. Enough along this line of investigation has been done to convince the thinker that the process of fusion and development has been both a gradual and a progressive one. But the fact remains that we are not ordinarily aware of anything but the result. We live on the crest of the wave of experience and profit by all that has gone before; or, to vary the simile, we are like spectators in the theater who see the finished play and do not know what goes on behind the scenes. Assuredly, the adult's ability to distinguish position, distance and size is an accomplishment. "For those

who are born blind," writes Bourdon, "space is a synthesis of tactile, muscular and joint sensations, and particularly of the tactile, muscular and joint sensations of the fingers, of the hand, of the arm and of the lips; for the normal man, on the contrary, space is essentially a synthesis of retinal sensations with tactile, muscular and joint sensations of the eyes and of the head. Now a long time after sight has been given to one born blind, he will still keep his old way of representing space."[2]

Before passing to the level of normal perception as dominated by sight, touch and movement, it will be well for us to note certain data which are calculated to restrain us from dropping into the dead-level view of space which has so often appeared in philosophy and mathematics. Had Kant meditated on these facts, his theory of space could not have been so neat and simple. It is a well-known fact to-day that the spatial extensities primitive to different senses are not correspondent, that there is something of qualitative incommensurability about them. "The interior of one's mouth-cavity feels larger when explored by the tongue than when looked at. The crater of a newly extracted tooth, and the movements of a loose tooth in its socket feel quite monstrous. . . . If two points kept equidistant be drawn across the skin so as really to describe a pair of parallel lines, the lines will appear farther apart in some spots than in others."[3] Of course, very few of these and similar facts are noted in every-day life because the interest of the individual is not directed toward them. We live in a space which has gradually been standardized because of our need to adapt ourselves to our environment, physical and social.

Perceptual Space.—Perceptual space arises at a level in which the synthesis of the various sources has been

[2] Bourdon, *La perception visuelle de l'espace,* p. 362.

[3] James, *Psychology,* Vol. II, p. 139.

pushed a long way. The role played by meanings and cues is the evidence of this fact. Visual and tactile space have so intimately been brought together that we pass from one to the other without any sense of difference. The one has come to mean the other in our spatial interpretations of things and distances and positions. But the part played by movement in the growth of perceptual space, as a sort of continuum of things in which we experience ourselves as living, can hardly be overestimated. Motor experiences organize, suffuse and knit together interpretatively the material contributed by sight and sound. Our vital interests are always forcing us to note positions and to estimate distances and directions, sizes and contours. Space becomes an affair of discriminations and estimations within a realm of apparently given things.

Now the perceptual level is likewise the level of things, their qualities and relations; it is the stage of common-sense realism. As we should expect, perceptual space reflects this situation and appears in completest harmony with it. Things have size, shape, position; they are at certain distances and in certain directions from one another. Space is not a thing, rather is it the complex of these characters. The whole perceptual field arises together as both quality and structure. The older philosophers and psychologists used to speak of an act of objectification by means of which the self passed from sensations to things. A little reflection should convince us, however, that objectification is a growth and not an act. It represents the passage from the vague and inchoate to the relatively clear and structural. Sensations are not first experienced in the head — how could they be? — and then extruded in some mysterious fashion. Objectification is a functional growth rather than a unique act.

Perceptual space is, then, the spatial character of the field of the individual's experience. It is a character which

ministers to all the meanings of thinghood and independence. The book which I see in front of me is appreciated by me as at once self-existent, perdurable, composed of printed paper, of a certain size and shape, so far distant and in such a direction.

But this spatial realm of perceptual things has three main characteristics which each one can verify for himself, and which are of considerable philosophical interest. It is, first, limited in extent. Our horizon always has a boundary, and near objects are more distinct and better defined spatially than are far ones. In short, each one perceives a concrete manifold of objects which is limited on both sides and also in the third dimension. I can see only so far in front of me and am compelled to turn my head in order to see objects too much to one side. In the second place, perceptual space is sensibly continuous, or unbroken by that which is non-spatial. It is obviously impossible to escape the presence of space in perception for it suffuses and relates the content of the field. All things have position. What we perceive in vision is of one character so far as extensiveness is concerned. Spatial material is at the heart of it genetically. If the term be not misunderstood, space can be called a *form* of things, that is, an omnipresent character with which we can contrast other, more variable features like color and odor. Space is a constant character of the field, while other characters undergo successive change. These elements vary independently. A thing may change its color while not changing its place; and, again, it may change its place without changing its color.

Empiricism vs. Nativism.—Psychologists and philosophers were long divided upon the question of the comparative innateness of space-perception. This problem is more a psycho-biological than a philosophical question,

that is, it is a question of genesis rather than a question of content and validity. But I do not think that it is going too far to assert that the historical controversy between those who believed space to be an innate possession of the "mind" and those who sought to derive it from elements essentially non-spatial in character has ceased in large measure to be a real one. The original antithesis has been outgrown in these evolutionary days. The Kantian form of nativism, called by Stumpf the psychic-stimulus theory, asserts that space is an innate form of the "mind" in which the chaotic manifold of qualitative sensations is arranged. Kant assumes that form and qualitative content are derived from different sources. The Humean type of empiricism sought to derive space from the arrangement (?) of qualitative points.

Kant's schema has many obvious weaknesses: it has a view of the mind which we would hardly accept to-day, and assumes that all connectedness is contributed by the agency of a transcendental ego of apperception. As a matter of fact, relations appear to be as sensuous in the first place and as naturally given as any other features of the perceptual field. The Kantian machinery strikes the present thinker as extra-natural and uninforming; and Kant's formulation is, historically, an attempt to supplement Hume rather than to make a thoroughly new analysis.[4]

That all perception rests upon, and involves, processes of discrimination and interpretation is a commonplace of to-day, but it was not so in Kant's day. That much should be pointed out in apology for Kant's formal intellectualism. Where we see genetic process, Kant saw a formal operation. It was this formal operation which involved the coming together of two unlike mental factors, the *a priori* and the *a posteriori,* the one contributed by the mind in a

[4] Cf. *Critical Realism,* Ch. 6. William James and James Ward—among others—have subjected the Kantian psychology to severe criticism. I hardly feel that there is need to kill the already slain.

free way, the other caused by something outside of the mind. We cannot permit a nativism which assumes an *a priori* element of this sort. All elements are innate in the sense that they are functions of the brain-mind under stimulation. The following quotation is, I think, a fair statement of contemporaneous psychological opinion: "We hold that the crude, vague feeling of extension, of volume, is a genuinely innate experience, unlike any other experience, and underived by mere experience from non-spatial psychical elements. So far we are nativists. On the other hand, we are confident that all accurate knowledge of the meaning of the space relations in our space world, all practically precise perception of direction, position, contour, size, etc., is a result of experience, and could never be gained without it. So far we are empiricists, holding to a *genetic* point of view regarding the development of our adult space-consciousness."[5] The spatial character of the field of objects which we suppose ourselves to perceive is a discrimination gradually achieved through material lending itself to the distinctions.

The Truth of Perceptual Spatial Judgments.—We have already suggested that judgments usually imply the setting of common-sense realism. That is, the judging individual is convinced that he perceives self-existent things which are the sources and centers of such executive agency as finds place in his world. He, himself, is only one—though a unique case—of these manifold things. In veridical perception, he becomes aware of such things and passes judgment upon their characters and relations. His sense of things does not always appear in explicitly judgmental form, but it can easily be so analyzed; and the judgments resulting will be considered true. Thus this red book in front of me is oblong in shape, quite thick, medium octavo

[5] Angell, *Psychology*, p. 141.

in size, two feet from me and toward the right. These spatial predicates can be tested by renewed perception and then accepted as finally valid—their exactness being adequate to my purpose. What shall we say of them?

It is evident that, within this setting of realism, I assume that I can note these features, or characters, and can subsume them under conceptual characters which I possess. The book is of this size. That is, I can discriminate its size and identify it just as I discriminate its color and identify it. And so with the other predicates. There is, so far as I can see, nothing mysterious in this process as long as it is kept within its setting and continues to be empirical. We have simply that interpretative interplay of perception and conception which is the heart of judgment. Relative positions, sizes, contours, distances, are distinguished and interpreted by means of concepts already in our possession as a result of past experience. Such judgments are as true as any other judgments directed upon sensible things. That this book before me is oblong is just as true as that it is red; that it is to the left of my typewriter is as certain as that it is cloth-bound. Yet such judgments are the *material* of our critical knowledge about the physical world.

Conceptual Empirical Space.—One further development of our spatial experience, which is at the same time a development of our idea of the physical world, deserves notice. Perceptual space is dominated by a perspective. It is the sensuously given expanse of things that stretches out from the percipient organism. Now empirical space is a development of this space somewhat as perceptual space is a growth out of sensational space. Empirical space is a conceptual combination and modification of the various perceptual spaces into the thought of a continuous world spread out in every direction. The vague appre-

hension of this larger, more inclusive world spread out in every direction floats in the background of our consciousness to qualify what we perceive at any one time. Thus there is no break between perceptual and conceptual space. One point of interest is, however, that we assume that things we perceive are in relation with things we do not perceive but acknowledge to exist. Moreover, these things are taken to be common to all people. Commonness is a meaning which suffuses things and, therefore, the spatial form and relations of things.

We need hardly linger upon the genesis of empirical space. Movement from place to place, with the areas combined by thought, reading, intersubjective intercourse, etc., all these factors assist in our conception of the world as a spatial expanse in which positions, distances, contours, sizes, directions can be distinguished. Direction is now referred to the sun and the points of the compass rather than to the body of the percipient; size and distance to units of measurement upon which agreement has been reached. It follows that we have here only a development of perceptual space. The setting is essentially the same—a common world of things open to discriminative apprehension. Measurement and a useful axis of reference introduce the chief changes in the field of objects. Another point should, however, be noted: most of the physical expanse is absent so far as perception is concerned. It is chiefly present in thought though absent in reality. Let us remember that, for common sense, experience supervenes upon things which are self-existent. We perceive things which are present and think of things which are absent.

This spatial, physical world has no apparent limits. Astronomy tells its marvels of constellations beyond constellations in pathless space, and the imagination grows weary in continuing a process to which there seems no

necessary end. But it is important to note that space is still neither a thing nor a semi-reality, for it is inseparably intertwined with bodies. It is not a receptacle into which things are put but a distinguishable character of related things. The world is not so much in space as it is spatial or extended.

Science deepens our appreciation of the spatial character of bodies. Common sense, being limited to surface views, misses the knowledge which comes from the combination of cross-sections. Mechanics with its study of stresses and strains, physics with its appreciation of interdependence, chemistry with its theory of rings and stereoisomeric substances, biology with its discovery of structure, all deepen the spatial aspect of things. He who has studied the detailed structure of the nervous tracts can hardly deny the reality of position.

Mathematical Space.—But the observational and experimental sciences are not the only sources of our deepened knowledge of space. They are the only basis of actual knowledge of the spatial nature of particular objects, it is true, but they are assisted by an abstract science which studies spatial characters as such, viz., mathematics. It is this non-physical science which assists the physical sciences through the setting-up of a correspondence between their material. The position we shall adopt is, that mathematical space is an abstractive construction resting ultimately upon characters gotten in perception. Mathematics is an intense study of the nature of spatial relations. The information it acquires is, therefore, interpretative of physical relations. If a body is a sphere, the results deduced mathematically about a sphere are relevant to my thought of this body.

The empirical basis of the ultimate material of mathematics is indicated by the history of the subject. But this material is conceptualized and studied intensively and in the

light of all sorts of methods. Analytic geometry and calculus are examples of what I mean by this inventive, intensive study. The results are, however, applicable to the material to which they are instrumental. It is for this reason that calculus is as instrumental to the physical sciences as is geometry, which is far more directly related to perception. In other words, the material of physical science overlaps in part the material of mathematics. I agree, then, with James Ward in his criticism of Kant: "Given only the pure space of Kant and the geometers, it is impossible to deduce the actual space of experience; but, given this, the deduction of that is intelligible."

Now how does this construction arise? We have already seen it well under way in our examination of common, empirical space. We learn to abstract the spatial features of bodies. In this way is obtained the concept of an empty space homogeneous in all directions. There can be no doubt that this process of abstraction is aided by the fact that bodies change their places, that is, their relative positions, while retaining their forms. This experience of rigid bodies which move from place to place enables the mind to advance to the conception of space as such, to spatial characters as such. This genesis has left its trace upon the geometrical concept. Just because rigid bodies have dominated our experience, we tend to think of the parts of empty space as immovable and exclusive of one another. What we do is to remove thinghood and non-spatial characters from the empirical expanse of ordinary perception. It is for this reason that I affirmed that content is emphasized in mathematical space and reference omitted. Mathematics is a non-existential science; it is not a science directly concerned with the physical world, even though its information is valuable for the physical sciences.

There are to-day both metrical and non-metrical geometries. So soon as geometrical objects are thought of as

having size, we enter the domain of metrical geometry, which is decidedly the more primitive type. But how is it possible to measure the magnitude of a geometrical quantity? Primitively by superposition.[6] The geometrician must be able to distinguish the two elements of position and form; and he determines equality by such a relative displacement as results in coincidence. "The figures are equal," writes M. Poincaré, "when one is able to superpose them; in order to superpose them, it is necessary to displace one of them until it coincides with the other: but how can one displace it? If we ask this question, it will be replied without doubt that one ought to do it without deformation and *after the fashion of an invariable solid.*" It is from this situation that the geometrical axiom of free mobility arises: Spatial magnitudes can be displaced without deformation. Now this axiom bears witness to the origin of mathematical space.

But mathematics has recently passed through a stage of reflective analysis in which search has been made for the smallest number of axioms which could bear the weight of a rational construction of different mathematical systems. For all the elements and processes involved, definitions are sought. There is, however, no real conflict between this demand and the acknowledgment of the genetic origin of the construction which is thus being rationalized. Reflection clarifies, discriminates, abstracts, defines, and logically relates elements of content, but it has its cues and suggestions in the material which has first been intuited. Math ematical space is, in other words, a development of the characteristics of empirical space, such as order, direction, distance and area.

Perhaps the contrast between empirical space and mathematical space can best be brought out by an examination of the idea of space held by prominent mathematicians.

[6] Cf. G. Lechalas, *Etude sur l'espace et le temps*, p. 31.

This method of approach will also give us the basis for a better understanding of the ideality or non-existential status of mathematical space.

Newcomb defines space as the totality of all positions into which a body could possibly be moved, were no impediment to motion in existence. "This totality," he writes, "forms a continuum, the conception of which is so elementary and fundamental that no definition can materially aid in its formation. To us the parts of space are all those places, infinite in number, to which or in which a body can be conceived to move or exist, and *vice versa,* we can conceive any body to move into a part of the infinite continuum which is formed by the totality of those places. Space is continuous not only in the sense that every part joins to the parts around it, but that every part is susceptible of indefinite subdivision."[7] What I have said of the empirical source of mathematical space stands out clearly in every sentence of this article. Spatial characters are enriched by operations, potential and actual, to which there are no assignable limits. Let us now turn to Russell. In his *Scientific Method in Philosophy* he makes the following remarks: "I do not see any reason to suppose that the points and instants which mathematicians introduce in dealing with space and time are actual physically existing entities, but I do see reason to suppose that the continuity of actual space and time may be more or less analogous to mathematical continuity. The theory of mathematical continuity is an abstract, logical theory, not dependent for its validity upon any properties of actual space and time. What is claimed for it is that, when it is understood, certain characteristics of space and time, previously very hard to analyze, are found not to present any logical difficulty." Continuity and infinity are, then, logical concepts which are applicable to space and time as derived from

[7] Newcomb, art. on "Space," *Dictionary of Philosophy.*

experience and which enable us to analyze and handle these characters. In accordance with this logical effort, point, instant, continuum and infinite are assumed or defined. Continuity is a property of series, and a series is continuous when between any two terms whatever, however near, another one can be placed. Again, infinite numbers cannot be reached by counting: they are a class quite distinct from finite numbers and have properties peculiar to themselves. It should be noted what a part number-theory has played in the formation of these concepts.

Mathematical space is, then, continuous and infinite, and there is no self-contradiction in these concepts. But mathematical space is more a system of operations and elements than a given expanse. For instance, for mathematical purposes, any object may be taken as a point or position. Again, when a mathematician speaks of an infinite number of points between any two positions on a straight line, what does he mean? He means that this portion, like any other portion, is a continuum. In a continuum there is no *next* position but always one *between*, and so on indefinitely. Thus we achieve the conception of a compact series. To assert that a line is infinitely divisible is not to regard it as made up of self-existent entities which are discrete and distant but to indicate a process which has no limit. Positions are foci of a conceptualized attention. They are the homologues in abstract space of things in perceptual space. Positions imply other elements because they are inseparable from distance and direction. Or we may put the same conclusion in the following way: if points were spatial, they could be further divided; if they were spaceless, they could not make up a piece of line-room. Infinite divisibility is the expression of this relativity of position in the total character of space.

In his treatment of space, Bergson often seems to confuse this abstractive space of mathematics with something

purely external. He does not do justice to the subsistent status of mathematical space. Time, or duration, is internal and pure heterogeneity, while space is external and pure homogeneity. Besides, I do not think that many mathematicians would agree with him that number is inseparable from space.[8] These abrupt antitheses are not empirical; they are dialectical—just the sort of method that Bergson claims to avoid. Even abstract space is not mere simultaneity; it is position, direction and distance. And are not these elements qualitative characters? But we shall be obliged to reexamine Bergson's doctrines when we come to treat time.

It is also necessary to say a few words about the theory that space is reducible to time. This theory has taken two forms. First may be mentioned the older associationist stress upon the succession of sensations in the formation of tactual space. But they forgot that this succession was accompanied by the character of coexistence in the complex of sensations in the resting hand, and that this latter character dominated the interpretation of the total experience. Positionness and extensity are characters which function actively in the construction of space. An element in the process, such as the temporal succession of new experiences, can be used in the making of a product in which temporal succession is not an element.

The second form of the temporal theory of space asserts that space is but a reversible time-order. We can pass from *a* to *b*, *c* and *d* and then back again. Of course we can. Space permits the passage of our attention or of our overt action back and forth over things. But the temporal order is that of events; in this case, our acts. Action implies space and space lends itself to action. To reach a distant object, I must pass by intermediate objects. But

[8] I believe that it is generally held to-day that numbers are concepts. Cf. Shearman, *The Scope of Formal Logic*, Ch. 6.

this does not contradict the fact that these objects were, all the time, in the relation of coexistence in the order of side-by-sideness, the basis of direction. And, by the way, is not the very expression "a reversible time-order" a contradiction in terms? It is an attempt to combine the different qualitative orders of space and time. Our actions are reversible, but the time-order is not.

Space as a Category.—Having now gained a fair idea of the genetic basis of conceptual space and also some insight into its character as a subsistent content, we are ready to consider the validity and meaning of this content when used as a category of knowledge about the physical world. That world is for us reality, the very substance of being. And it is by an irresistible pressure of the material of knowledge that we think of it as extended. Some thinkers, it is true, hold that this pressure of our objective experience to consider reality spatial in its character, that is, to hold spatial predicates applicable to it, leads to a disastrous conflict between reason and instinct. But I think that even they must concede that the burden of proof rests upon them.[9]

Space claims, then, to be a cognitively objective category, to mediate knowledge about reality. Judgments of position, relative size, contour, distance and direction are, therefore, referable to the physical world. To say that these judgments are valid and contain information referable to an independent realm is to think this realm spatial, *for these elements give the very meaning of space as a category.* Space as a category is not a thing to be pictured. To assert that the physical world is spatial, means, not that the physical world is *in* a non-dynamic receptaculum analogous to mathematical space, but that certain predicates

[9] Cf. Bradley, *Appearance and Reality,* Ch. 4. For another reason, Bergson also attacks the validity of space as a category.

are interpretative of its actual constitution and nature. While we need not exaggerate the amount of information given by spatial judgments nor the depth of insight contributed by them, it is likewise unnecessary to deny their significance. The morphologist has his work to perform as well as the physiologist. An organism has structure as well as function. We shall learn, as we proceed, that the categories supplement one another and are intertwined in adequate knowledge.

An Historical Retrospect.—Science always acts as a stimulus to the active thinker, and he who does without this stimulus is apt to swing around in a dialectical circle, trusting all the time to the advent of some pictorial intuition. The first philosophical view of real space identified it with a void in which atoms somehow exist. This void, the μὴ ὄν of Greek philosophy, was a sort of semi-reality which could be filled and which could also remain empty. The fact to note about this outlook is its failure clearly to distinguish between mathematical space and the void. Physical reality is thought of as passively dispersed.

Plato identified matter and extension—just as Descartes did after him—and was led to reject the void of the atomists. But, here again, mathematical space tends to be reified. When Descartes asserts that the defining essence of matter is extension, he is in the hands of a mathematical rationalism which pretends to intuit reality rather than to gain an elementary knowledge applicable to it. He does not realize that mathematics is a non-existential science which can be developed for its own sake as well as be used as instrumental to the various physical sciences.

The development of mechanics gave rise to the Newtonian conception of nature which gave a semi-reality to space as such. For Newton, space is as a whole hyperphysical, an independent, fundamental variable in relation

to which the world directs itself. We are led to think of it as a connecting continuum in which things are. Thus its unity gives unity to the world of things in space. This means that the unity was not so much held to arise out of the nature of the physical world as out of this menstruum. It is only fair to Newton to point out that there have been different interpretations of his system, especially in regard to such a problem as action at a distance. Yet, when all is said, absolute space is for him a receptaculum. His system is impregnated with what may be called mathematical realism. Space as a category of our knowledge of the physical world is confused with the content of mathematics.

To make Newton's position somewhat clearer to the reader, let us glance at the teaching of a contemporary mathematician. In *The Problems of Philosophy* Mr. Bertrand Russell writes as follows: "Thus we may assume that there is a physical space in which physical objects have spatial relations corresponding to those which the corresponding sense-data have in our private spaces. It is this physical space which is dealt with in geometry and assumed in physics and astronomy." I interpret this position as similar to Newton's, although I must confess that Mr. Russell's philosophy is fundamentally unclear to me. What is this physical space? Is it the physical world conceived as spatial, that is, in terms of spatial predicates? Or is it a second kind of reality, a receptacle?

Faraday inaugurated another movement which may be regarded as a reaction against a conventionalized Newtonianism. His experiments led him to adopt the view that all physical action is mediated by intervening physical conditions. The physical world, in other words, has its own dynamic continuity and does not need to borrow it from a real, hyperphysical, absolute space. The whole drift of modern science has continued in this direction.

It is time that mathematical objects and content be separated from physical reality.

When I assert that a physical thing is extended, I mean that it is measurable in terms of units superposed directly or indirectly upon it, that it actively excludes other things, that its parts have a characteristic external order of position in relation to each other, and that these facts can be related to other facts which can be brought out by experiment. In this sense, I have the right to say that physical things are extended without meaning that they are in an absolute space as a sort of receptacle or that they possess an attribute of which I can gain an idea of a copy sort. Hence, to assert that nature is extended is to maintain that human knowledge about nature contains elements of a certain content. Physical space is, then, the physical world known as spatial. The more we know about the intimate structure of the physical world, the more we know about real space. So far as mathematics is of assistance to science, it does not come between nature and our knowledge as a disturbing factor, and the thinker must rid himself of the habit of assuming that physical things are in a homogeneous medium made of positions.

Kant's Antinomies.—Kant sought to prove that the assumption that reality is spatial lands us in certain contradictions which can be avoided if we once admit that space is phenomenal and holds only of phenomena. His argument has played such a role in the history of philosophy and is still taken so seriously that it must be examined.

Kant's thesis is, that the world is limited with regard to space, that is, that it has a determinate and finite size. His method is to point out the contradiction in the opposite assumption. "In that case," he asserts, "the world would be *given* as an infinite whole of coexisting things." But to the realist the expression "given" is ambiguous. Does

it mean "exist"? Either we can have a conception of an infinite totality of things (or had we better say, an infinite extent?), or we cannot. If we can, such an infinite totality *may* exist. If we cannot, there is no reason to assert what is meaningless to us. Now Kant seems to suppose that, in order to conceive an infinite world, a successive synthesis—presumably by human minds—would have to be looked upon as completed. But is this necessary? A standing infinite would rather be one which was thought of as inexhaustible by enumeration or measurement. For Kant, it is one which should, but cannot, be enumerated.

His antithesis is, that the world is infinite in respect to space. Here, again, he works by disproof of the contradictory. If the world be finite, it would exist in an empty space without limits. We should, therefore, have not only a relation of things *in* space, but also of things *to* space. But such a relation would be a relation to no object and therefore it is nothing. Hence, the world is not limited with regard to space, that is, it is infinite in extension.

Let us look at this strange argument. In the first place, it assumes that a finite world must exist in empty space. We, however, have shown that such a space does not exist, since it is the mere reification of an abstraction. Kant then argues that, because such an empty space cannot limit the physical world, this latter must be infinite. But this argument makes the assumption that what is not limited from outside is infinite—an unwarrantable assumption.[10]

We are forced to conclude that Kant disproves neither his thesis nor his antithesis. We are left, therefore, with a choice to be determined on other grounds. And Kant's purpose is defeated.

What must be our own conclusion in regard to this

[10] For the quotations from Kant see Müller's translation of the *Critique of Pure Reason*, pp. 344ff.

age-old question? We may put it in this fashion: If the terms, finite and infinite, are contradictory adjectives applicable to the physical world, no *a priori* reasoning can decide for one as against the other. Inductive science, alone, with its superstructure of tested theory is potentially able to decide the question, and the day has not come when this can be done with any certainty. I would, however, like to call attention to certain points sometimes misunderstood.

The principle of the conservation of energy does not by itself point in either direction. It simply maintains that energy is not lost or gained; it does not inform us how much energy there is in the universe. Again, the second law of thermo-dynamics, popularly known as the law of the dissipation of energy, sets a problem for the course of nature, but does not inform us whether nature avoids it by being infinite or by being able to reverse the process. The truth is that these principles are more intimately bound up with the category of time than with space.

If nature be finite and thus of a determinate size, as many facts seem to attest, this character does not necessitate it to have a smooth boundary beyond which electrons could not dash. The boundary needs must be dynamic and one of varying equilibrium. If gravitation have significance for the minutest portions of physical reality, its internal pull will determine the "flaming boundaries" of the world. The void is perfectly thinkable, for it is purely a condensed negative proposition and not a thing. It is nonsense to assert that the void *is*—if this expression be interpreted as an existential proposition. It really means that not one of the things we are accustomed to find is present. But, it will we demanded, can we not ask the question, What lies beyond? Certainly we can; and the void is the denial that anything lies beyond.

Is Nature Infinitely Divisible?—Mathematical space is infinitely divisible. But it does not follow that a physical thing is infinitely divisible. In the case of the one, we are concerned with an operation of thought correspondent with the nature of the material operated upon. In the case of the other, we are confronted with a problem of fact. Certainly, human beings cannot divide a physical thing into an infinite number of parts. The structure of things seems to be atomic. Of late, theories of energy have drifted in the same direction—as comes out clearly in the quantum-theory of Planck. Nature—to use James's expression—seems to bud off drop by drop. Infinite divisibility would seem to involve a passive sort of homogeneity; and this is alien to the dynamic, structural character of the world as revealed in experience. To substitute mathematical space and its characters for reality—however valuable instrumentally at times—is to beg the question.[11]

II. TIME.

The usual feeling in regard to time has been expressed by no one better than by Saint Augustine: *Quid est tempus? Si nemo ex me quaerat, scio; si quaerenti explicare velim, nescio.* No concept is more baffling and has more subtle apparent contradictions than has time. As one other writer has put it: "All things live in time and it lives in nothing; all things die in time and death is not able to attain it." But may it not be that it is this very mystical tendency to substantialize time that leads us into our difficulties? Because we have not sufficiently distinguished the various

[11] "On the discontinuity-theory, time, change, etc., would grow by finite buds or drops, either nothing coming at all, or certain units of amount bursting into being 'at a stroke.' Every feature of the universe would on this view have a finite numerical constitution. Just as atoms, not half or quarter atoms, are the minimum of matter that can be, and every finite amount of matter contains a finite number of atoms, so any amounts of time, space, change, etc., which we might assume would be composed of a finite number of minimal amounts of time, space and change." James, *Some Problems of Philosophy*, Ch. 10, p. 154.

meanings and contexts which the term has, we are the more easily led to regard time as a mysterious form or receptacle in which events somehow happen. Let us see whether we can treat this concept in a genetic fashion as we did space, and in this way succeed in relating each level to a context in which it becomes significant. We shall, I think, find that the preceding examination of space will aid us—especially in the study of kinetic and mathematical time. But there will also be important differences between space and time to note, due to the fact that each is *sui generis.* Each bears upon and introduces us to fundamentally distinct characteristics of reality.

The elementary experience which is at the foundation of what we roughly call time is the immediate feeling of change. "The mere fact that B follows A in consciousness does not of itself constitute the consciousness of B as following A. On the other hand, we must not jump to the conclusion that, because the sequence A B is not in itself the cognition of that sequence, it is therefore not experienced at all in any way. We must distinguish between consciousness of change or duration and change-consciousness or duration-consciousness. Change in consciousness may be felt without being cognized as change, and duration may also be felt without being cognized as duration."[1] What Professor Stout refers to here is the distinction between two mental levels. For instance, we can feel that there is a similarity between two objects long before we are able to analyze out the element which is essentially common to both. Cognition is a more reflective attitude which supervenes upon the relatively unreflective flow of experience. Probably no writer has brought out the significance of these feelings of change, these *transitive experiences,* better than William James; at the same time, James emphasized the difficult problem with which intro-

[1] Stout, *Manual of Psychology,* pp. 384-85.

spection is confronted in its search for them. "Let any one try to cut a thought across in the middle," he writes, "and get a look at its section, and he will see how difficult the introspective observation of the transitive tracts is. As a snowflake crystal caught in the warm hand is no longer a crystal but a drop, so, instead of catching the feeling of relation moving to its term, we find we have caught some substantive thing, usually the last word we are pronouncing, statically taken and with its function, tendency and particular meaning in the sentence quite evaporated."[2] As this writer points out, the denial that these transitive feelings or experiences exist has led to absurd mistakes in theory of knowledge. Sensationalism of the associational type was tempted into asserting that consciousness consists of sensations and their copies and derivatives "juxtaposed like dominoes in a game, but really separate." In other words, these early empiricists mistook the results of a partial analysis at a reflective level for the actual flow of experience and thus reached a false idea of the immediate data of experience. They reached such a false idea, not because reflective analysis is unveracious or falsifying, but because it was in their case controlled by preconceptions. They did not introspect delicately enough; they were too rough-and-ready and too biased. To-day, however, there is pretty general agreement that we feel change long before we analyze out the factors and think of them as in a sequence.

But the sense of change is only one of the elements which reflective analysis can note in perceptual time. Just as important is the feeling of duration or lapse of time. All individuals have an ability to estimate roughly the extent of duration of a process or activity. It is the task of the psychologist to explain the conditions of this sensing of duration. The indication is that it is connected, in part,

[2] *Principles of Psychology,* Vol. I, p. 244.

with certain recurring activities which help to give a rhythm to consciousness, and, in part, with what may be called the cumulative effect of the process of attending. "When we are listening to a sound," writes Stout, "our experience is different at the end of one minute from what it is at the end of two minutes, although the sound itself may not have altered in quality."[8] There is a qualitative difference in the experience, as time passes, which adds an experiential differentia to the sense of change and complicates it. The more we penetrate to the experience itself and remove, as it were, the images with which habit has veiled this experience, the more we realize its unique qualitative nature. If the aim is to be true to the experience itself, the picture of a stream or a line is totally inadequate. Let us call this interwoven sensing of change and duration the basic time-experience.

In personal time, we have, then, the immediate experience of both change and duration. These characters are data for the philosopher, although the psychologist may recognize it as his task to find their conditions. Moreover, we must admit that, as experienced characters, there is no contradiction between change and duration. A sense of the lapse of time fits in with the sense of change as its complement. While we cannot infer the one from the other, they harmonize so completely that there is reason to think of them as supplementary aspects of one complex experience. Both bear witness to the unity in diversity of consciousness.

The Specious Present.—The actual span of consciousness gives the experienced, or specious, present. This empirical present is not an indivisible instant of time but a changing span of some dimension. What its exact dimension is must be left to experimental technique to discover.

[8] Stout, *op. cit.*, p. 386.

The point to note is, that perceptual experience knows nothing of mathematical instants.[4] To assume them as is implied in the query, whether the felt present is made up of moments and is infinitely divisible, is to confuse levels and standpoints. It is the great advantage of the genetic method that it prevents the occurrence of such pseudo-problems.

The present is not an arrested span of consciousness but, rather all the consciousness there is. It is a flow whose content is always changing. "If the present thought is of A B C D E F G, the next one will be of B C D E F G H, and the one after that of C D E F G H I—the lingerings of the past dropping successively away, and the incomings of the future making up the loss. These lingerings of old objects, these incomings of new, are the germs of memory and expectation, the retrospective and the prospective sense of time. They give that continuity to consciousness without which it could not be called a stream."[5] If we disregard the complications introduced by memory and expectation, which represent an additional story added, as it were, to the current of perceptual happening, we are in a better position to gain clear ideas of the basic elements of the time-experience. These are developed and amplified by conception rather than changed.

The specious present is the moving content of the stream of consciousness. This span contains change of content, transitive feelings of a temporal sort, and felt distinctions which join with, and develop, the sense of change. In a

[4] "In short, the practically cognized present is no knife-edge, but a saddle-back, with a certain breadth of its own on which we sit perched, and from which we look in two directions into time. The units of composition of our perception of time is a *duration,* with a bow and a stern, as it were—a rear-ward and a forward-looking end. It is only as parts of this *duration-block* that the relation of *succession* of one end to the other is perceived....The experience is from the outset a synthetic datum, not a simple one; and to sensible perception its members are inseparable, although attention looking back may easily decompose the experience, and distinguish its beginning from its end." James, *Principles of Psychology,* Vol. I, p. 609.

[5] *Ibid.,* p. 606.

chord of music played arpeggio, the various notes can be distinguished as both simultaneous and successive. They are heard together and yet in the order of succession.

Thus our perceptual experience presents us with four characters relevant to our idea of time, viz., change of content, sense of duration with a feeling of more or less, order of succession, and simultaneity. Along with these characters there is often another—the sense of growth or summation. This last character appears prominently in the experience of directed activity which has a goal. A more passive form appears in music. Heard melodies consist of tones which shade transitively into one another and yet mass together into a whole whose richness depends upon the musical capacity of the listener.

In the analysis of perceptual time, emphasis has usually been placed upon the irreversible order of succession characteristic of events. And yet, significant as this feature is, attention to it alone is apt to encourage a linear notion of time. It will be well for us to note the aspect of simultaneity of events as well as their succession. Simultaneity is the order of co-occurrence which characterizes many events. Consciousness is not thin and merely linear; instead, it is complex in content. I can hear the peal of thunder at the same time that I see a man scurrying across the street. In the busy streets of a city how many distinct actions can be noticed practically at once! We shall find that this order of events opens up a tremendous field for the imagination and lends itself to a significant development in science. Simultaneity will enable us to link time with space and give it a depth of location it otherwise is apt to lack.

The Addition of Memory and Expectation.—The "just past" and "not yet" of perceptual time are, it has been suggested, the germs of expectation and memory. But

the expansion of time which accompanies the growth of these attitudes and contents is critical, for it gives a reach and reference which is basic for time as a cognitive category of knowledge. The stability of our time-meanings —the past, the present and the future—depends upon this supplementation by a larger range of events than the "specious present" can offer. We are lifted to, and live in, a wider temporal horizon than perception permits. The events which are marshaled in order are ideas and not sensations. There is, in this freedom from the original limitations, something analogous to the movement from perceptual space to common, or empirical, space. Conception is, here, not something opposed to the nature of perception, but rather something which develops and ripens the potentiality of the latter. The train of successions opened to the mind by memories and expectations is held together in one massive series and touched by the vivifying flow of life; and the whole is suffused by that sense of change and of duration which we have seen to be so basic and primitive. Due to this contact, the higher level of personal time retains an individual flavor and reference. It has a direction, is never empty, and has the uniqueness of the stream of consciousness of which it is a part.

Common, or Standardized, Time.—This higher level of personal time shades insensibly into common, or standardized, time. What should particularly be noted is the infusion of a spatial framework through various needs, among which is that of interpersonal intercourse. We must not, however, jump to the conclusion that such intercourse is, alone, responsible for this introduction of space. The more subjective estimates of duration are found by the individual to be too dependent on emotions and bodily conditions to be trustworthy as standards guiding the phases of behavior. For these various reasons which re-

enforce one another, the individual is led to resort to changes in things conceived to be indifferent to these more fluctuating personal factors. Of course, this acceptance of the neutrality of processes in nature is confirmed and, in large measure, caused by the testimony of other who are not *at the same time* subject to our hopes and fears. It is, therefore, in the attempt to get beyond the personal equation in duration-estimation that stress is laid upon features of the physical world—the standpoint being here that of common-sense realism—which correspond to temporal order and harmonize with, or correspond to, the sense of duration. Does this standardization affect any of the time-characters? When rightly understood—as it not always is—it does not.

We have already emphasized an analogy between the conceptual development of time and the conceptual development of space. Another analogy is in order. Just as measurement by superposition is an advance upon measurement by the eye, because harmonizable with the latter and yet more exact and certain, so measurement of duration by motion is an advance upon a more intra-organic estimation. It must not be forgotten that the essential elements of change, order and duration remain unaltered.

Thus empirical time moves outward to nature. And this movement works in favor of the cognitive use of time in our knowledge of nature. Time becomes differentiated and, in one of its forms, fitted to become a category of the physical sciences. It is easy to understand how a chronology for the external world arose. A uniformly recurrent process would best serve as the standard, and, accordingly, the daily and yearly movements of the sun were adopted—with the historical result that history, or the process of the world, was reckoned by years, days, hours, etc. We are all of us familiar with this system, but we are not so familiar with the shift in time-estimation which occurs as we

pass from personal time to this standardized time. "Shakespeare tells us that time travels 'in divers paces with divers persons'; Newton tells us that time moves at a constant rate. Shakespeare's time is evidently subjective time, and Newton's objective time."[6] The contrast is between intra-organic time-estimation and measurement of events by commonly appreciated standards based on processes outside of the organism. No intuition of a literally objective time is demanded.

Mathematical Time.—Common time very easily links itself with mathematical space to become mathematical time, infinitely divisible and potentially infinite in extent. Hobbes has expressed this transformation so clearly and, withal, so naively that it will be well to quote him: "As a body leaves a phantasm of its magnitude in the mind, so also a moved body leaves a phantasm of its motion, namely an idea of that body passing out of one space into another by continual succession. And this idea, or phantasm, is that which (without receding much from the common opinion, or from Aristotle's definition) I call time. . . . And yet, when I say time is a phantasm of motion, I do not say this is sufficient to define it by; for this word time comprehends the notion of former and latter or of succession in the motion of a body, in as much as it is first here and then there. Wherefore a complete definition of time is such as this, *time is the phantasm of before and after in motion.*" Motion is one case of perceived change, a case for which measurement can easily be devised.

Movements are best represented symbolically by a line with a direction, thus ———>: in such a symbol, there is a quantitative character and also the characters of order and direction. Hence, the line symbolizes duration and succession. The minimal elements of the construction are,

[6] Stout, *op. cit.*, p. 498.

measurable line-room to represent the relative duration, and positions, apprehended together and yet thought of as successive to correspond to temporal order. Mathematical time, then, uses space as its measurable basis and superposes upon this a different kind of order, that of succession instead of coexistence.

Now, in our study of space, we saw that the more developed levels must not be substituted in a literal way for the lower levels. To think of perceptual space as really mathematical space disguised is to lay oneself open to all sorts of pseudo-problems. Mathematical space is, in part, a self-sufficient conceptual realm; in part, instrumental to knowledge about the physical world. There is continuity in spatial characters and also difference in their setting and use. In the same way, to seek to reduce personal time as an experience to mathematical time is absurd. *The time characters are present in both, but their setting is different.* Mathematical time is conceived by us to be infinitely divisible, infinite in extent, homogeneous and empty. The characters are abstracted from their plangent source. It is against the identification of personal time, as the interwoven flow of conscious life, with space-time that Bergson rightly objects.[1] *But the flow of life is not time as a category.*

Kant's Antinomy.—Mathematical time is, as it were, the abstracted order of common time thrown upon the background of space. It is a conceptual construction reflecting essential characters and yet characters here loosened from

[1] "Were I to look at it closely, I should see that this abstract time is as immobile for me as the state which I localize in it, that it could flow only by a continual change of quality, and that if it is without quality, merely the theater of the change, it thus becomes an immobile medium. I should see that the construction of this homogeneous time is simply designed to facilitate the comparison between the different concrete durations, to permit us to count simultaneities, and to measure one flux of duration in relation to another." *An Introduction to Metaphysics*, p. 46. I fear, however, that Bergson forgets that temporal order is qualitative.

their normal content, which is events and changes. We can note the order in which all events do come and consider it apart from any particular events. The order is, in this sense, the form of all possible events which must be simultaneous and successive with respect to other events. Thus there is a fundamental continuity between the genetic levels of the time-experience, what may be called an identity of essence. Mathematical time can, therefore, be instrumental to knowledge of the physical world in a way completely analogous to the space of mathematics. The material of knowledge is given in perceptual experience; and yet the more conceptual stages, which mental operations produce, develop and employ this material for conscious ends.

This identity between the essential characters of common and mathematical time being granted, we can proceed to discuss Kant's famous antinomy. We shall see reason to believe that it is as much of an error as that which was directed against the validity of space. Naturally, we shall grant to Kant that neither space nor time is a thing-in-itself. Our different epistemology sets a new formulation. We ask, Is time a category potentially or actively interpretative of the character of reality?

Kant seeks to prove the thesis that the world has a beginning in time by showing the absurdity of the opposite proposition. "For if we assumed that the world had no beginning in time, then an eternity must have elapsed up to every given point of time, and therefore an infinite series of successive stages of things must have *passed* in the world. The infinity of a series, however, consists in this, that it never can be completed by means of a successive synthesis. Hence an infinite past series of worlds is impossible and the beginning of the world is a necessary condition of its existence."

What we are here really dealing with is our conception

of time. Time is an order of successive events. Let us take a line and consider any arbitrary point as the present. Does it follow that I must think of the portion of the line, which extends to the left and symbolizes the past, as finite? Assuredly not. One of the initial mistakes of Kant was to start with an assumed past moment and work toward the present instead of with the present and working backward. So far as our thought follows the method of synthesis, we begin with the present; and the infinity of time means that there is no conceivable end to the movement into the past. Kant speaks as though time were a stream flowing into the present. There is a double danger in this approach: the image suggests a source, and we confuse our thought with the flow of things. An infinite flow does not involve a human synthesis of an infinite collection of events. The critical realist does not demand too close a parallelism between the process of thought and the process of reality. Thought is retrospective and supervenes upon reality. Hence, to think of the world-process as without a beginning is an empirical affair of which we find ourselves quite capable.

Time as a Scientific Category.—What kind of knowledge of the physical world does time cover? We shall realize in the case of time, even more clearly than in that of space, that human knowledge is not an intuition of the physical world. Knowledge implies intuited material and the use of that material in a cognitive way, but what is intuited is mental and not the physical object.

The first point to note is the character of the measurements upon which science builds its facts. Scientific time is at once a measurable quantity and an order of succession. Some process—preferably a movement—is taken as a standard, and other processes are referred to this unit. If two processes begin and end at the same time, they "occupy"

the same time. Let us take an example to make this method of measurement clear. Suppose that we wish to know how long a certain chemical process takes. We note the positions of the hands of a watch at the moment we put the chemicals together and also at the exact moment the reaction ceases. We measure the one process in terms of the other standardized one to which we relate all other processes. This measurable correspondence is the type of scientific time-quantity, and it is for temporal knowledge what the superposition of things is for the spatial knowledge of nature. In both cases, our knowledge consists of ratios, not of intuitions of inherent properties. Perception is a means to knowledge.

The standard process which science has adopted is, we have said, movement. It might have been other processes, like the loss of heat by bodies, but practical conveniences led to the selection of movement. The point to stress is, that the prime requisite of the reference-process is its capacity for exact measurement. That processes, as we say, occupy time means two things: first, they are experienced by us as corresponding to an immediately estimated duration; second, that there are changes of a successive order. The scientist undertakes to measure these aspects and relate them to one another. What process is selected as a standard of reference and what unit is adopted are arbitrary so far as nature is concerned—a fact that makes us realize that knowledge is a human affair and is knowledge about nature rather than a reproduction of something external to man. But the ratios secured are not at all arbitrary. Given the method and the unit, and the result is determined by reality itself. Nature dictates a response to man's questions. But the questions and the language of the response are human.

When the thinker reaches this conclusion, he is led to seek confirmation in the more theoretical reflections of

scientists themselves. And it is interesting to find that scientists are more alive to-day to such questions than ever before. In every field there is an increasing demand for exact definition and discriminating analysis. In regard to space and time, the theory of relativity has produced a marked degree of reflection. Thus in his examination of the theory of relativity, Dr. Silberstein treats of the "definition of physical time or the selection of a clock or time-keeper, to be employed for the quantitative determination of a succession of physical events."[8] Let us consider his summary of the method adopted by science to work out a suitable standard.

"Suppose," he writes, "we do not limit ourselves to the investigation of motion only, but are concerned with every possible kind of physical phenomena, such as conduction of heat or electricity, diffusion of gases or liquids, melting of ice, evaporation of a liquid, etc., and that we propose to describe the progress of these phenomena in time, to trace their history, past and future. How are we, then, to select our time-quantity t?" Newton's absolute time flowing at a constant rate—whatever that may mean—could not help us since we have no clock to measure this absolute time. The result is that science selects some standard process like the rotation of the earth and adheres to it so long as it can relate other processes to it. When this cannot be done with ease, the standard process is examined more thoroughly to see if it is variable. "Thus astronomers have come to the conclusion that the earth as a clock is losing at the rate of 8.3 seconds per century and they have given up the earth as their time-keeper and substituted for the sidereal time t a certain function $T = \varphi(t)$, slightly differing from t, as their new 'kinetic time.'"

It is obvious that science has relinquished that naively realistic attitude toward kinetic time which still lingered

[8] Silberstein, *The Theory of Relativity*, Ch. 1.

in the mind of Newton. The above analysis of scientific time fits in exactly with the position which our own critical analysis forced us to take. The universality of scientific time follows from the identity of the reference made. We may say that the whole physical world is in *one* time: when properly analyzed, this only means that the same, identical process can be brought into relation with all the physical processes which we know.* Hence, the oneness of the world's time is expressive of the fact that all processes in nature can be compared and measured by human ingenuity. The world is spatially one, and so it lends itself to these comparisons.

An interesting result, which we might otherwise have missed, now stares us in the face. The unity of scientific time really rests upon the spatial unity of the physical world. The processes of change which are measured are changes in the physical world, localizable with respect to each other. We move our eyes hither and thither to note the changes which are running their course and keep tab of them in the light of the movements on the clock's face. It is obvious that the unity of scientific time implies the spatial character of nature. These two fundamental, and yet elementary, quantities hold of the same world. The elements of the two quantities are, however, essentially different. Space signifies order of coexistence in distance: its character comes out best in the experience of solidity. The idea of change is alien to its content. When we think of nature in terms of it, we think of coexistent bodies whose parts exist alongside of one another. Time, on the other hand, signifies an order of change qualified by duration. Such change we think of as *in* bodies. The distinctness of the two categories can be brought out in this fashion: Conceive of the physical world as inert and changeless. Would

* The modern theory of relativity deals with the assumptions underlying measurement. It has led to an analysis of scientific space and time long needed.

time have any meaning for such a world? But our world is different. It is both spatial and temporal. Only when we think of it in terms of both do we grasp it properly. Thus they are co-valid of nature. Physics recognizes this correlation in the acceptance of the four-dimensional manifold of space-time.

Temporal Distinctions.—Let us next glance at certain distinctions characteristic of personal time in order to see whether we should carry them over to time as a category of scientific knowledge about nature. I refer to the time-meanings, the past, the present and the future. In personal time we distinguish the now from the past and the not-yet. It will be remembered that in perceptual space we distinguish the here from the there, chiefly with reference to the organism. What becomes of the temporal contrasts at other levels?

The present of common time is more a construction of arbitrary limits. It may be a minute, a day, a year, according to the context and interest. This relative character of the present holds also for mathematical time, for in it there is nothing to distinguish one moment from another except their order. The present of such a time is an arbitrary portion of time-room which can be made as small or as large as desired. There is no present in its own right in mathematical time. The situation is analogous to the arbitrariness of any "here" in mathematical space.

But what shall we say of the present for kinetic, or scientific, time? Does our knowledge of nature reveal a present which stands out in an absolute sense and can be measured? Obviously not. What science offers us consists of processes which can be correlated with the accepted time-intervals. Theoretically, such an interval can be made smaller and smaller; practically, this process of comminu-

[9] We shall examine the question of continuity elsewhere.

tion has a limit set by technique. The general measurements which are obtained in science give quantities which can be treated as infinitely divisible. Whether the natural process itself is of this type remains, however, to be seen.[9] The preliminary knowledge which gross measurement contributes is incapable of answering such a penetrative question. Be that as it may, it follows that kinetic time offers no natural present in any way analogous to the specious present of consciousness. Let us not, however, condemn science for giving only the sort of knowledge it can obtain.

Change the Objective Basis of Scientific Time.—If time be an order, it must be an order of something. In our own consciousness, it is an order of experience. What do we think of as in an order of succession in nature? The answer which leaps to our minds is change. Real time is change, or, to put it the other way around, change, as cognitively conceived, always involves an order of succession.

But the character of real change is, itself, a problem. Is change continuous or discontinuous? Again, does change involve an order in nature? We must postpone the detailed consideration of these questions to another chapter, but certain points may be noted now. In the first place, change in consciousness seems to involve both continuity and discontinuity. There is often no preparation for what happens. Thunder breaks in upon silence in a cataclysmic way. The principle of the threshold, likewise, suggests abrupt transitions. But it may be retorted that the nervous system carries the increasing strain cumulatively. To this it may be replied that there are different rates of change, and that nature often works like a gasoline engine by a series of quick explosions. At other times, change seems to be progressive and continuous.

When we ask ourselves whether change involves an

order of time, the answer seems clear. Change in consciousness does so, for that is the exemplar from which the category of time is derived. But when we think of changes in systems independent of consciousness, a difficulty arises. The past ceases to exist, and there seems to be no natural present. Knowledge about nature is not the same as nature, and we have a right to expect a divergence between the form of knowledge and reality. Let me illustrate the point. The scientist furnishes us with knowledge about a motion by describing the *path* traversed and the time-rate of the motion. But the body moving does not carry its path with it. Only man with his memory is able to connect a past position with a present one. The moving body has no such coordinating memory. When this difference is once grasped, we realize that knowledge about a motion is not the same as the actual motion. Paradoxical as it may sound at first, we must admit that nature produces events *according to an order* and that man arranges them *in an order*. The stretched-out order of past and present is founded upon nature and agrees with nature but does not exist in nature. Knowledge and reality are not identical.

The "now" is present experience in contrast to past experience, which is remembered, and future experience which is anticipated. The remembering and the anticipating are present, while what is remembered is dated as past and what is anticipated dated as future. A little care would avoid all difficulty here. We should say that events are past rather than in the past. What we mean is, that certain processes or activities have ceased, though they once did occur. Their existence was their presentness. The "now" of nature is what is going on there.

It follows that temporal contrasts should not be read too naively into nature. When we come to consider the category of causality, the importance of this warning will appear in all its force. Can the cause, which is past, pro-

duce the effect which is present? Our analysis of time will enable us to meet such questions with assurance.

Real time is change: but what is change? Does it imply activity? Consciousness is a stream whose content is changing, that is, old content lapsing and new content coming. It is not a *thing* which changes so much as a series of changes. But when we think of the physical world, we conceive of it as *that which* changes or in which changes occur and not as a series of changes. If we can master a metaphor, we can say that "nowness" of nature is the reality of the things of which it is composed. In our thought of reality, we get rid of that threat of transiency which qualifies consciousness and gives much of its sadness to the present moment. It is evident that we are here on the track of the category of substance, of that which is the seat, source and center of change but whose existence is not imperiled by change. It is reality which changes and at the same time persists.

A Return to Kant's Antinomy.—To those who have grasped the implications of the above analysis, it will be clear that the usual view has been reversed. Instead of nature being in time, time (change) is in nature. So understood, time suggests neither beginning nor end to the world.

Had the world a beginning? We do not ask whether it had a beginning in time. Now, if the world had a beginning, it must have been because it was created, or because it arose out of nothing. But is there any good empirical reason which suggests creation? Is not the burden of proof on those who assert it? Science possesses no data which lead in that direction. To those who protest that they are forced to think of a beginning, it may be pointed out that they concede that God is eternal. It is evident that the thought of an eternally existing reality is a

common possession. Let us pass to the other alternative While I can't absolutely disprove that the world arose out of nothing, I find the idea opposed to all the tendencies of my thought which urge me to seek a cause for what comes to be. We are here face to face with the so-called problem of being.[10] As James has so well said, "Not only that *anything* should be, but that *this* very thing should be, is mysterious! Philosophy stares, but brings no reasoned solution, for from nothing to being there is no logical bridge."[11] But philosophy is essentially an attempt to understand the world as it exists. And, besides, not-being is a concept founded upon being by negation.

The complementary problem—Is the physical world eternal?—can be discussed in a few words. The position taken toward the previous question implies the answer to this one. The facts are in favor of conservation of some kind. What it is that is conserved is another matter and will demand consideration later. If the universe be a spatial system, what holds of subsystems can be applied to reality as a whole. The more science secures data in favor of conservation, the more it urges on us the view that nature is eternal. And by eternal I mean, not changeless, but never ceasing to exist.

Summary and Suggestions.—In the previous discussion on Space, we were led to the conclusion that spatial judgments are valid of nature and that the elements of the spatial category, such as distance, position and order, correspond to, and reveal, the structural character of the world. But we also realized that these elements appeared in those innumerable detailed judgments which constitute science. It was their commonness which constituted space a genuine category of knowledge. What is true of space

[10] Cf. Schopenhauer, *The World as Will and Representation,* Appendix 17.

[11] James, *Some Problems of Philosophy,* p. 39.

is also true of time. Temporal order and measurements give us knowledge about nature. Yet these categories require development and deepening: they are apt to be conceived in too passive and mathematical a form. While space blossoms out, with the increase of knowledge, into the categories of dynamic relation and internal organization, time deepens into the idea of processes of caused change. Dynamic elements enter to give body and energy to our concept of nature. Into the framework furnished by space and time all the other categories fit. No valid predicate can conflict with them. Reality is spatial, and this spatial reality changes.

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